**Network Centric Warfare:
A Revolution in
Military Affairs**

**VADM Arthur K. Cebrowski
CNO-N6
27 August 1997**

"There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things."

Niccolo Machiavelli, The Prince

Network Centric Warfare:
A Revolution in Military Affairs

"... it's a fundamental shift from what we call platform-centric warfare to something we call network-centric warfare."

Admiral Jay L. Johnson, USN
Chief of Naval Operations

What is a Revolution?

"A fundamental change ..."
- in thinking
- in visualizing
- in preference

"A displacement of the conceptual network ..."

"Non-cumulative developmental episodes ..."

"A change of paradigm ... "

Previous Scientific Revolutions

Astronomy | *Copernican Revolution* |

- Ptolemaic (Geocentric) ➡ - Copernican (Heliocentric)

Physics | *Newtonian Revolution* |

- Galilean Dynamics ➡ - Newtonian Dynamics

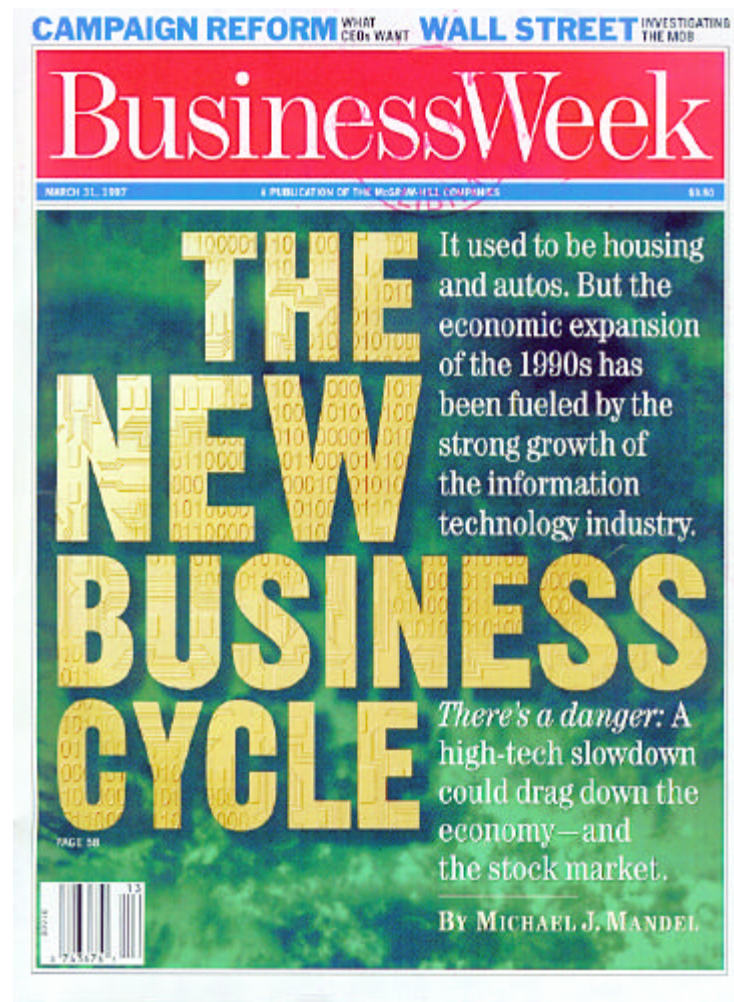**Physics** | *Modern Physics* |

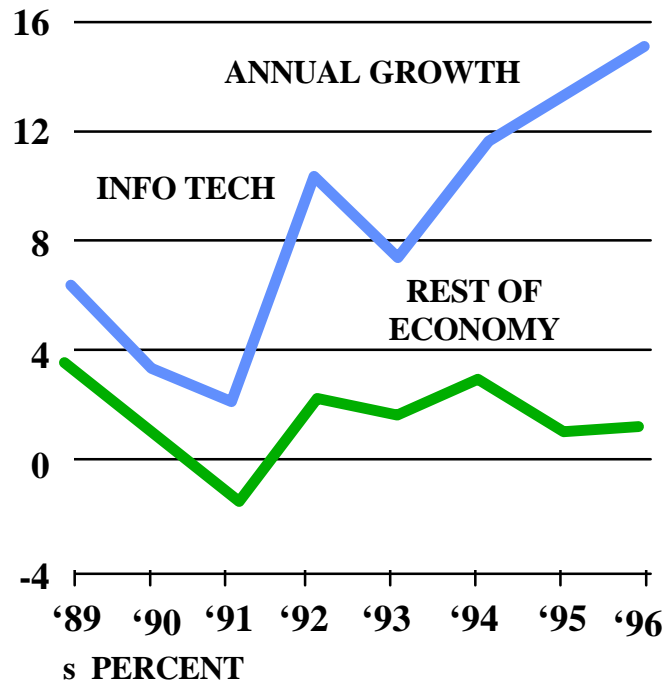- Newtonian Dynamics ➡ - Relativistic Dynamics
- Quantum Mechanics
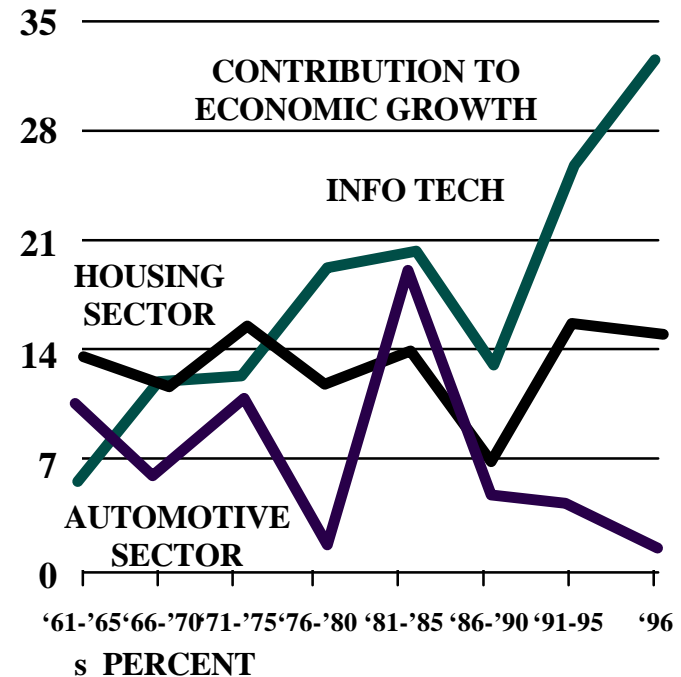
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The New Business Cycle

The New Business Cycle

The Information Technology Sector Is Accelerating . . .

ANNUAL GROWTH

INFO TECH

REST OF ECONOMY

16
12
8
4
0
-4

'89 '90 '91 '92 '93 '94 '95 '96

s PERCENT

. . . Dominating The Expansion . . .

CONTRIBUTION TO ECONOMIC GROWTH

INFO TECH

HOUSING SECTOR

AUTOMOTIVE SECTOR

35
28
21
14
7
0

'61-'65 '66-'70 '71-'75 '76-'80 '81-'85 '86-'90 '91-95 '96

s PERCENT

Implication: Information Technology is new engine of economic growth

Copernicus

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The Changing Dynamics of Competition

Coevolving Ecosystems

Information Technology

- Platform Centric → - Network Centric

Business

- Company Centric → - Network Centric
  - Increasing Returns vs. Decreasing Returns

Warfare

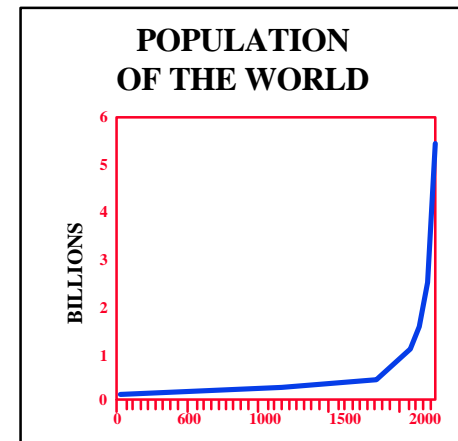- Platform Centric → - Network Centric
- Attrition → -- Speed of Command

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Coevolving Information Ecosystems

- **Corporate Strategies**
  - **Sun Microsystems**
    - » **"The Network is the Computer"**
  - **IBM**
    - » **Old Focus: Platform Centric ("Big Iron")**
    - » **New Focus: "Network Centric Computing"**

Trends

GROSS NATIONAL PRODUCT

HEALTH CARE COSTS

NUMBER OF PRISONERS
State and Federal

BIRTHS TO UNMARRIED WOMEN

AIR MILES TRAVELED
Domestic and Foreign

POPULATION OF THE WORLD

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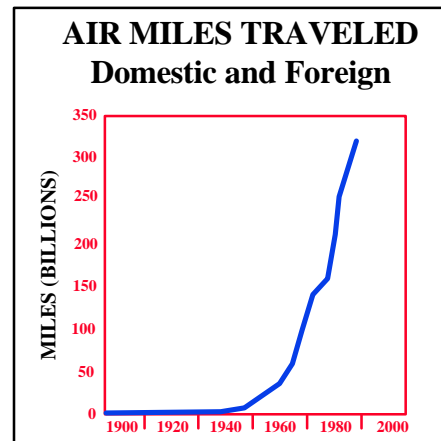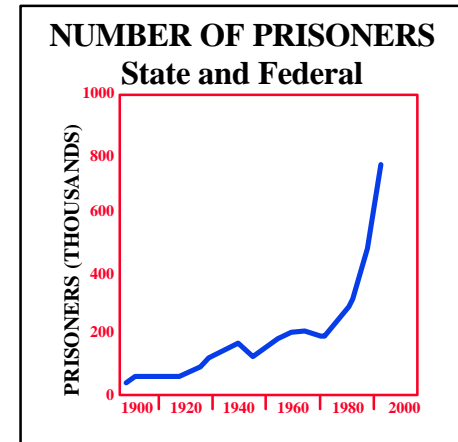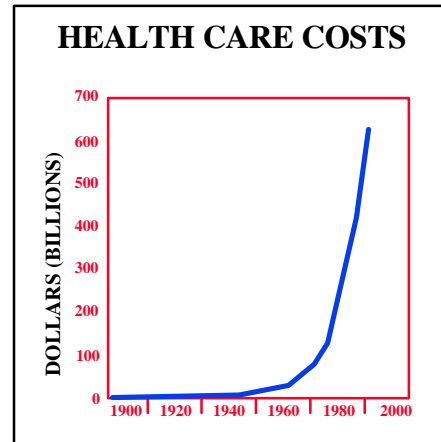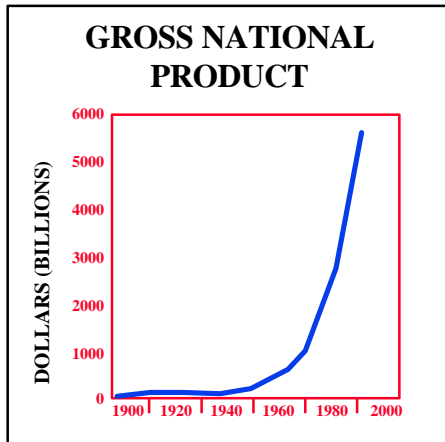
Communications is Catching Computing Speed

Legend:
- ○ **Processor speed: Observed MIPS**
- ● **Network capacity: Observed mega-kilometers/second**

Forecast MIPS

Forecast megaKIPS

Y-axis: **Performance MIPS, megaKIPs** — 0, 2,000, 4,000, 6,000, 8,000, 10,000, 12,000

X-axis: 1992, 1994, 1996, 1998, 2000, 2002
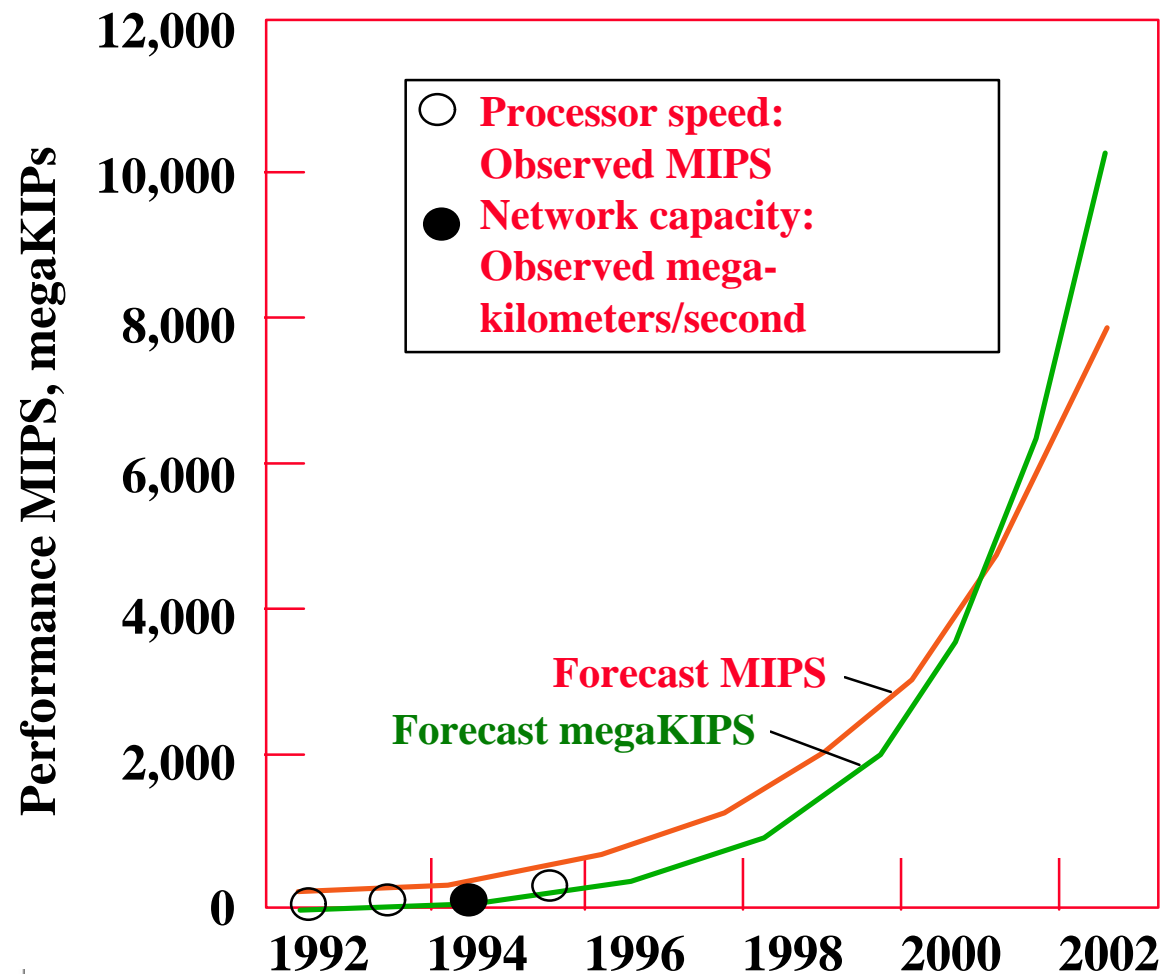
Source: Professor Ted Lewis, *Computer* Magazine, May 1996

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The Changing Dynamics of Competition

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- Platform Centric ⟶ - Network Centric

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Warfare

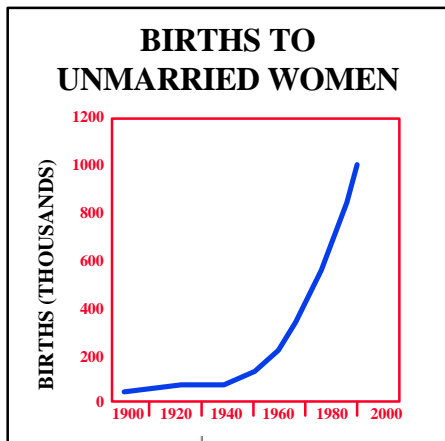- Platform Centric ⟶ - Network Centric
- Attrition -- Speed of Command

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Increasing Returns vs. Decreasing Returns

- **Decreasing Returns (Economy A)**
  - Market share equilibrium
    - » Increased costs to achieve greater market share
  - Absence of Mechanisms for Product Lock-in
    - » Competing products are Interchangeable
  - Examples:
    - » Consumer Non-Durables
      - Food
    - » Consumer Durables
      - Automobiles

- **Increasing Returns (Economy B)**
  - Lack of Market Share Equilibrium
  - Mechanisms for Product Lock-in
    - » Competing products are not interoperable
    - » Network Effects
    - » User skills
  - Examples:
    - » Standards
      - VHS vs. Beta
      - MAC vs. DOS/Windows
    - » User Skills
      - "QWERTY" Typewriter
      - Ethernet vs. ATM

Increasing Returns Case Study: Beta vs. VHS
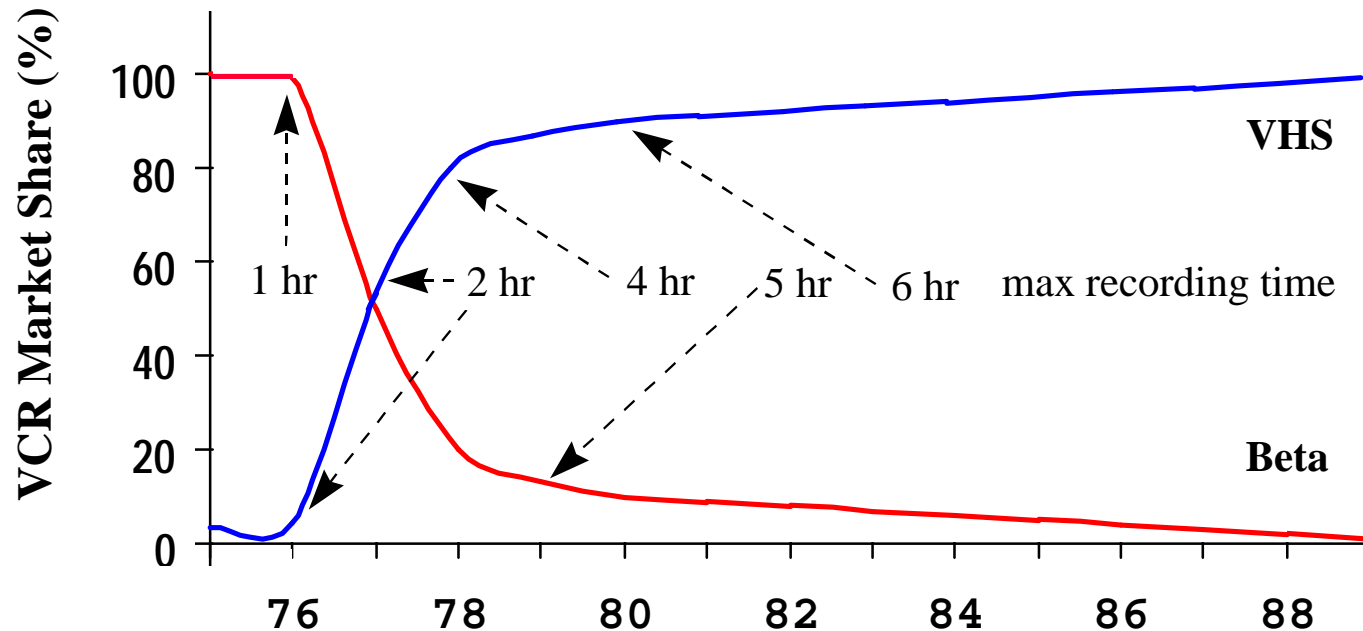
Operational Requirement	2 sitcoms	1 movie	football game
Recording Time	1 hour	2 hours	4 hours

Source: Dominant Technology Adaptation Study, 1997,
Center for Naval Analyses

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Increasing Returns Case Study: Personal Computer Operating Systems

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Competitive Space: Retail

- **Competition between Retail Ecosystems**
  - **Wal-Mart vs. K-Mart**
  - **Business Model**
    - » **Maximize Value to Customer (Price, Selection, Service)**
    - » **Maximize Profit for Retailer**
      - **Maximize number/profitability of transactions**
        - **Develop awareness of what customer is buying**
        - **Supply stores what the customer is buying**
      - **Minimize costs of transactions**
        - **Cost of Advertising**
        - **Cost of Labor**
        - **Cost of Plant (Retail Stores, Warehouses)**
        - **Cost of Products (Price retailer pays to supplier of products)**
        - **Logistics Costs: Inventory (Retail Store, Warehouse, Intransit)**

Competitive Space Case Study: Network Centric Retailing

Wal-Mart's Retailing Ecosystem
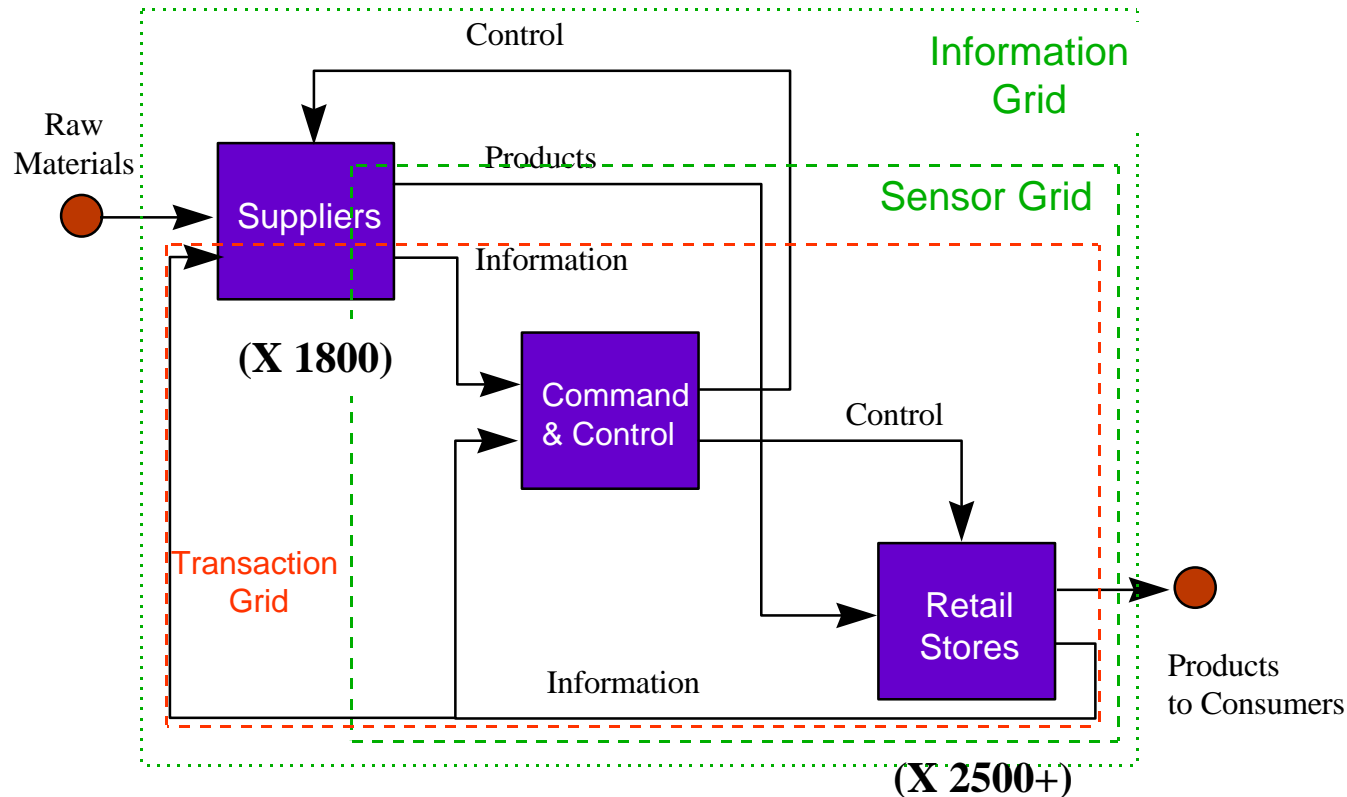
1996 Results [1]

Sales: $104.9 Billion
Earnings: $3.056 Billion

IT Spending [2]

1996: $1,027M
1995: $452M

Competitive Edge [3]

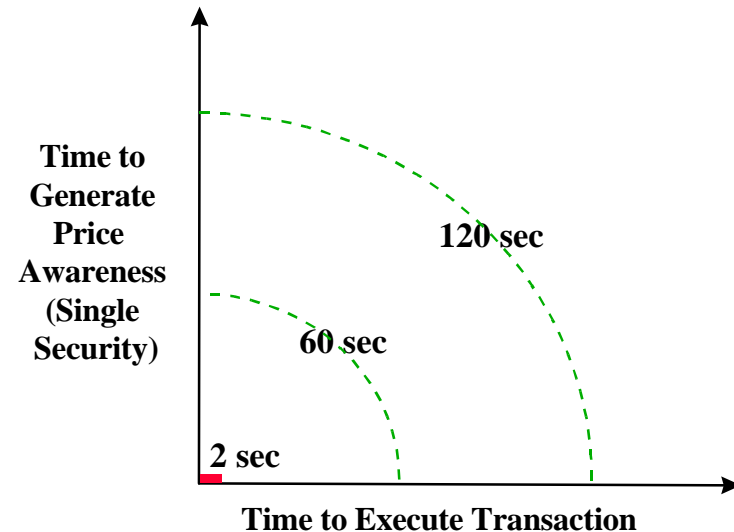Cost of Distribution
3% of Sales
(vs. 4.5 to 5% for
Competition)

"Competitive Space" Awareness Emerges as key
Competitive Advantage in Retail Sector

Source: 1. Investors Business Daily, 1997
2. International Data Corporation, 1997
3. *The Death of Competition*, 1996

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Competitive Space Case Study: Fixed Income Securities Trading

- Competition Based on Time
  - **Market: U.S. Government Securities**
    - » **Notes and Bonds**
  - **Securities Traders:**
    - » **Deutsche Morgan Grenfell, Inc. Goldman Sachs, Merrill Lynch, Cantor Fitzgerald, etc.**
  - **Asymmetries in Customer Service**
  - **Business Model**
    - » **Maximize Profit for Trading Firm**
      - **Increase number and profitability of Securities Transactions**
    - » **Maximize Value to Customer**
      - **Price: Bid/Ask**
      - **Service = Transaction Time**

Time to Generate Price Awareness (Single Security)

120 sec

60 sec

2 sec

Time to Execute Transaction

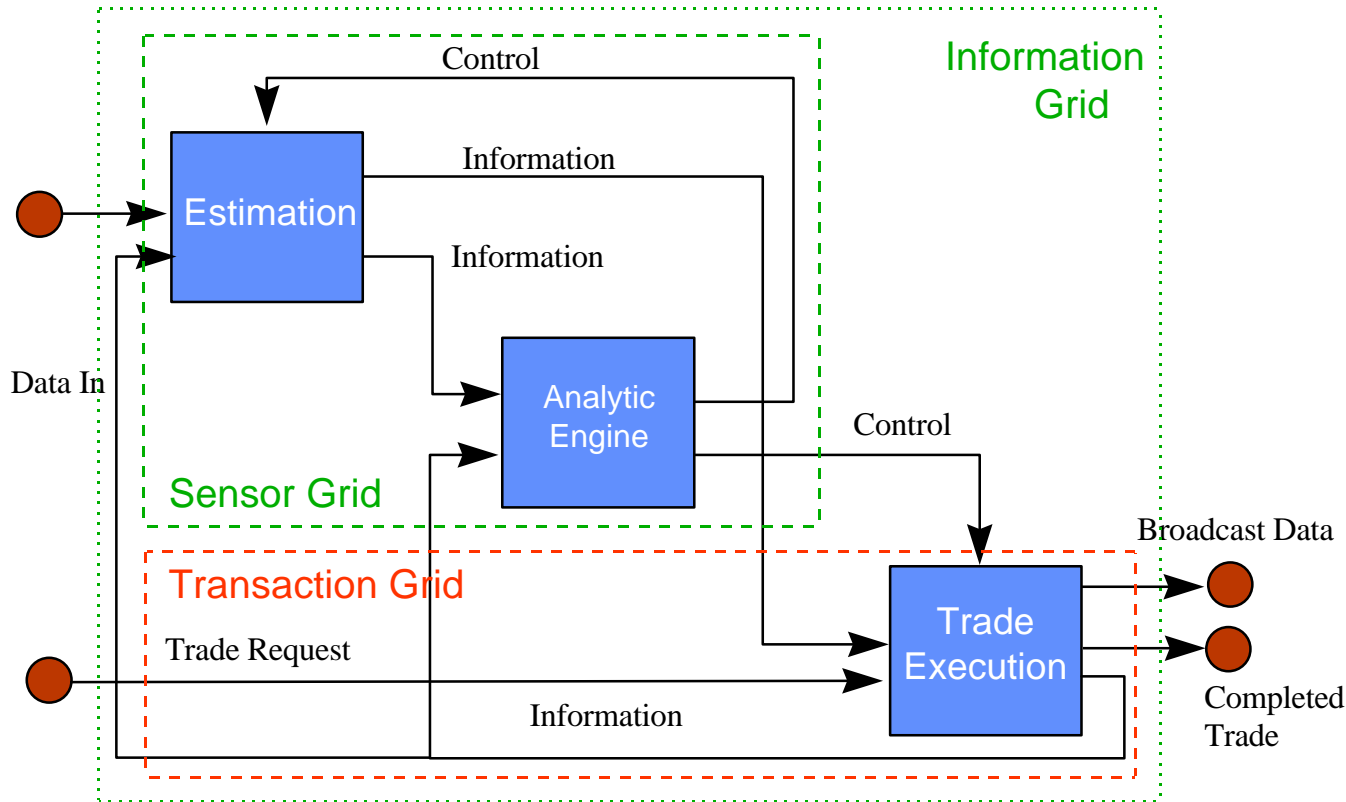- **AUTOBAHN**
  - **- 2 sec**
  - **- 95% of the time**
- **Competition**
  - **- 30 sec to 90 sec**
  - **- 30 sec: 10% of the time**

Source: Interview w/ Christopher J. Carroll
                    Managing Director,
                    Global Electronic Trading, DMG

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Competitive Space Case Study:
Fixed Income Securities Trading

"The Network is the Market^{SM}"

Company:

Deutsche Morgan Grenfell, Inc.

Service:
AUTOBAHN

Competitive Edge [1]

Increased Trading Volume

Monthly Increase:
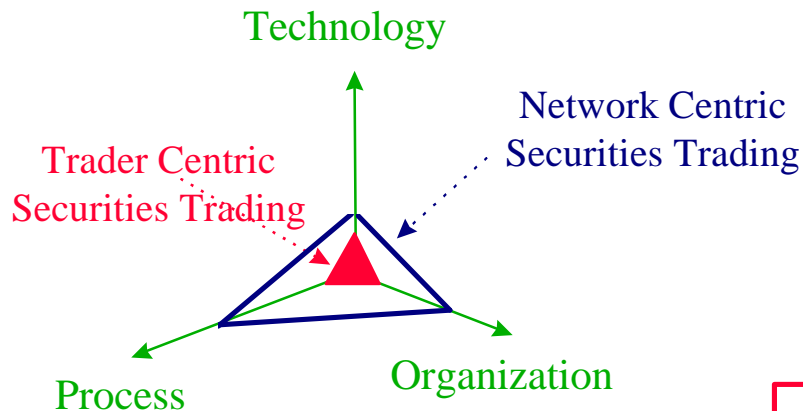- **22% - 24%**

Projected Annual Increase:
- **800%+**

"Competitive Space" Awareness Emerges as
Competitive Advantage in Securities Trading

Source: 1. Interview w/ Christopher J. Carroll
Managing Director,
Global Electronic Trading, DMG

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Competitive Space Case Study: Fixed Income Securities Trading

Competitive Advantage Emerges from Coevolution of Organization, Process, and Technology

Technology

Network Centric Securities Trading

Trader Centric Securities Trading

Process

Organization

Information Superiority Increases Competitiveness

10^4 — 100% Awareness (All Securties)

10^3

Information Advantage — 10^2 — 100% Awareness (Single Security)

10^1

10^1 10^2 10^3

Annual Increase in Trading Volume

Quantifiable Information Advantage
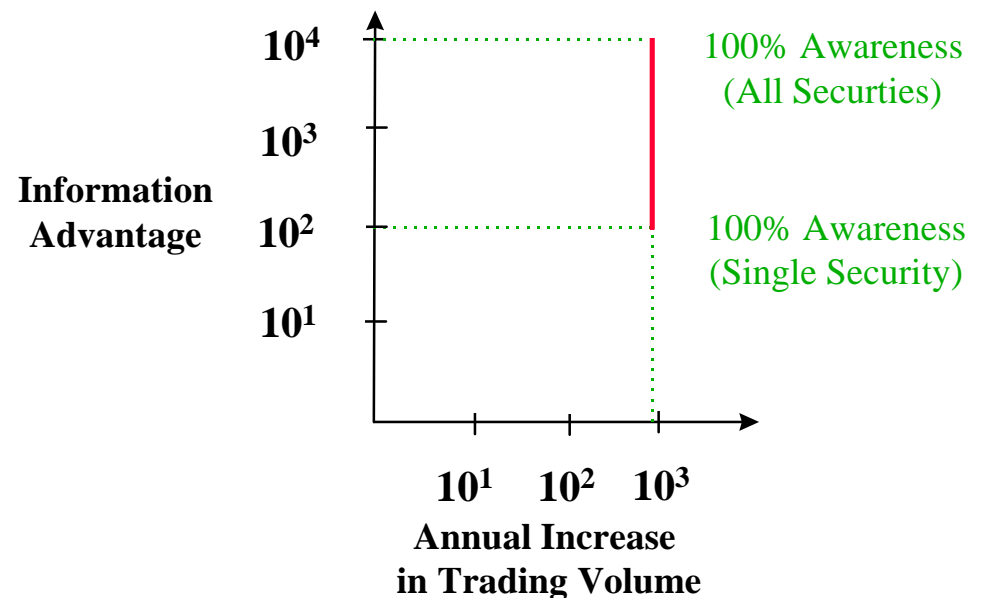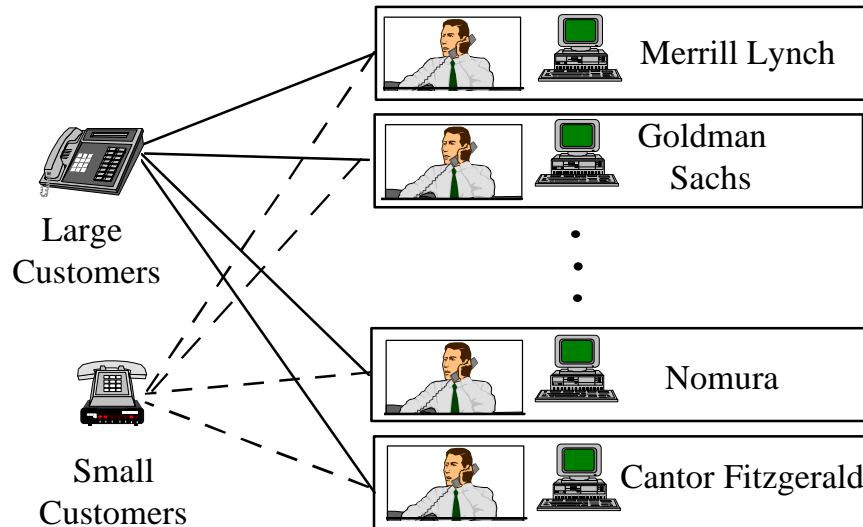Quantifiable Increase in Competitiveness
Highly Correlated

Source: Interview w/ Christopher J. Carroll
Managing Director,
Global Electronic Trading, DMG

Competitive Space Case Study:
Fixed Income Securities Trading

"Trader Centric" Securities Trading

Large Customers

| Merrill Lynch |
| Goldman Sachs |
| Nomura |
| Cantor Fitzgerald |

Small Customers

- **Securities Traded via Voice Transaction**
  - Step 1: Customer Develops Price Awareness (Single Security)
    - -- 3-4 Phone Calls: Parallel or Serial
  - Step 2: Customer Selects Party for Transaction
  - Step 3: Trade Executed
- **Total Elapsed Time**
  - Large Customer (Parallel: 50+ sec / Serial: 160+ sec)
  - Small Customer (*Time to Access Trader Drives Timeline*)

"Network Centric" Securities Trading

All Customers   Autobahn
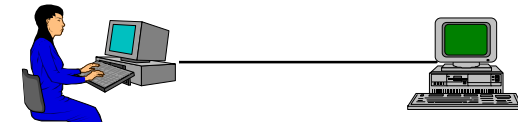
- **Securities Traded via Electronic Transaction**
  - Step 1: Customer Receives Price Broadcast
    - -- Real time broadcast of Bid/Ask Prices
    - -- 100% Price Awareness
  - Step 2: Trade Executed: 2 sec
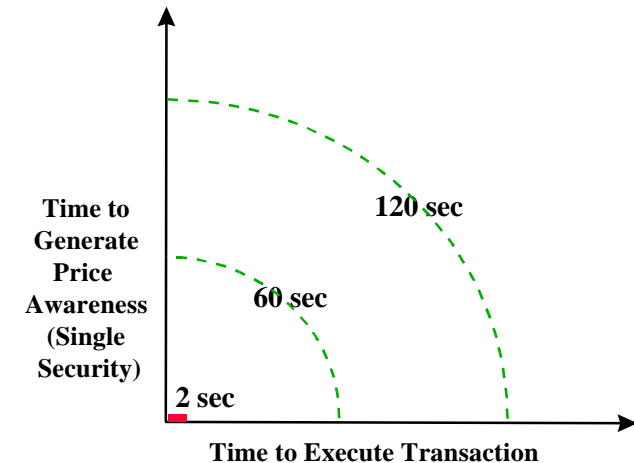
Time to Generate Price Awareness (Single Security)

120 sec

60 sec

2 sec

Time to Execute Transaction

Source: Interview w/ Christopher J. Carroll
Managing Director,
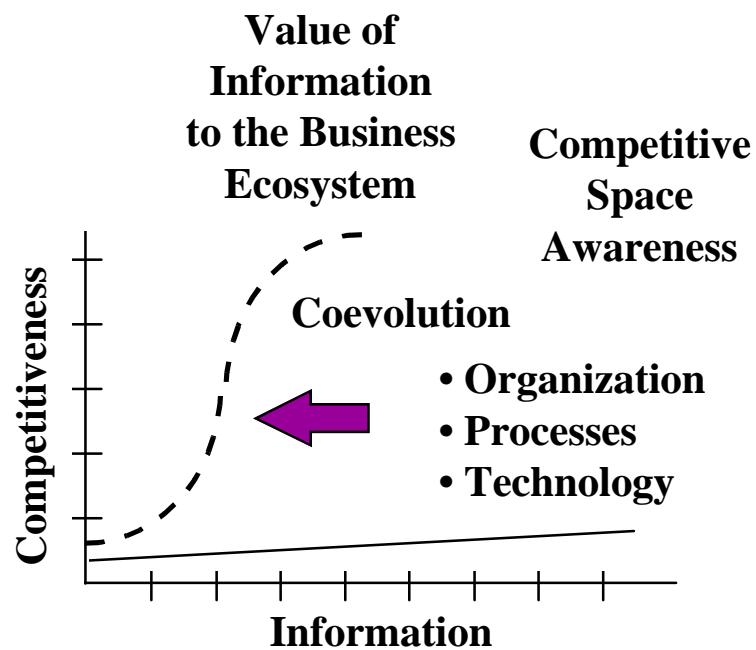Global Electronic Trading, DMG

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Coevolving Business Ecosystems

- **Source of Competitive Edge**
  - **Information grids enable network centric computing**
  - **Sensor grids create awareness of competitive space**
  - **Transaction grids exploit awareness to provide a competitive edge**
- **Emergence of new modes of competition**
  - **Competition between Business Ecosystems**
    - » **Enabled by coevolving information ecosystems**
    - » **Competition based on time**
  - **Competition characterized by Increasing Returns**
    - » **Implications for Warfare**

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Coevolving Business Ecosystems

Value of Information to the Business Ecosystem

Competitive Space Awareness

Coevolution

- Organization
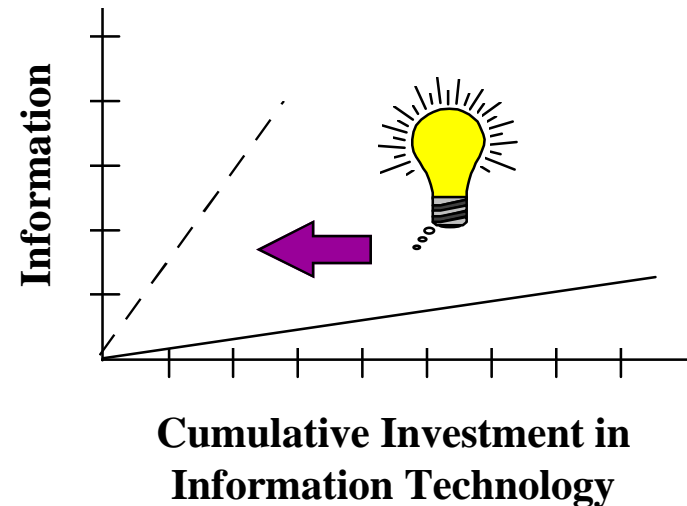- Processes
- Technology

Competitiveness

Information

- **Information**

  Can be translated to a competitive advantage through coevolution of organization, processes, and technology

Information

Cumulative Investment in Information Technology

- **Information**
  – Implement at minimum cost with reduced cycle times

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Coevolving Ecosystems

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- Platform Centric   ➡   - Network Centric

Business

- Company Centric   ➡   - Network Centric

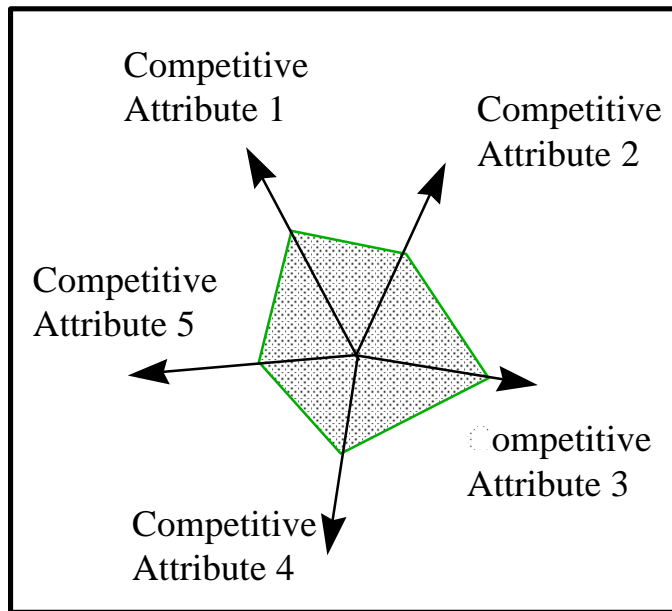   - Increasing Returns vs. Decreasing Returns

Warfare

- Platform Centric   ➡   - Network Centric

- Attrition   -- Speed of Command

Strategy vs. Operational Effectiveness

Strategy

Operational Effectiveness[1]

Competitive Space Selection

Competitive Attribute 1

Competitive Attribute 2

Competitive Attribute 5

Competitive Attribute 3

Competitive Attribute 4

Nonprice value delivered to customer

high value

low value
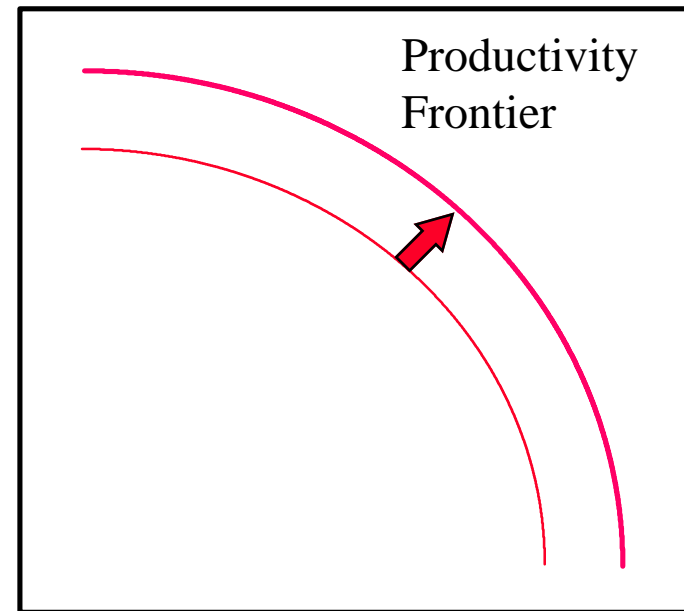
high cost

low cost

Relative Cost Position

Productivity Frontier

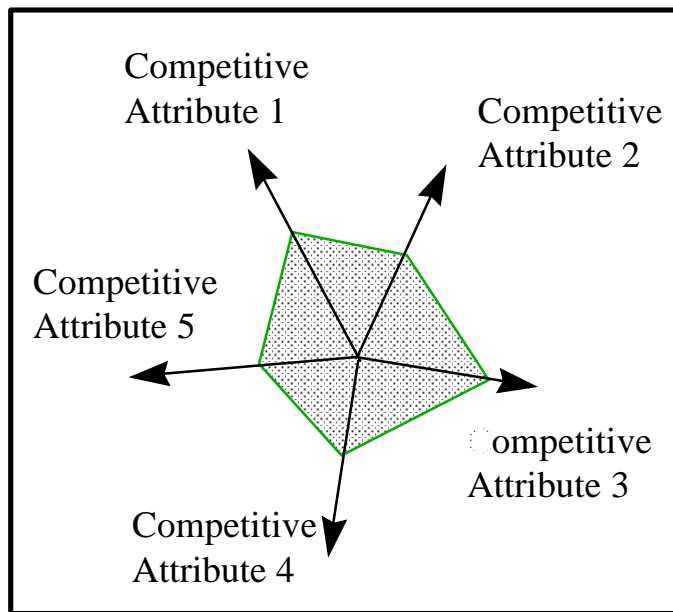1. Source: "What is Strategy?," *Harvard Business Review,* (November-December 1996)

Strategy

Strategy A

Strategy B
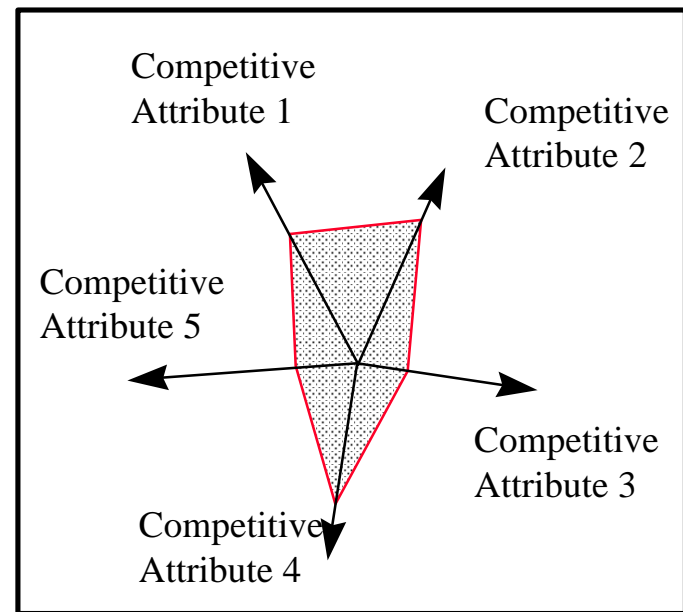
Strategy is About Selecting a Competitive Space

Strategy

Football

Speed

Mass

Speed of
Command

Self-
Synchronization

Continuity

Soccer

Speed

Mass

Speed of
Command

Self-
Synchronization

Continuity
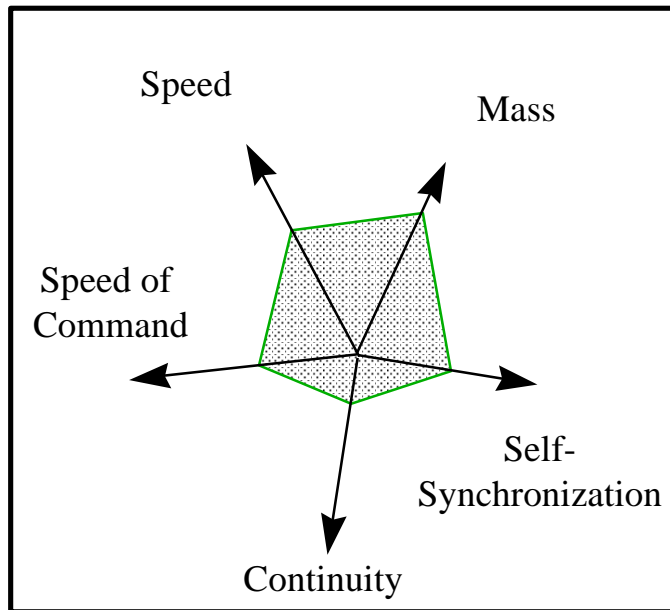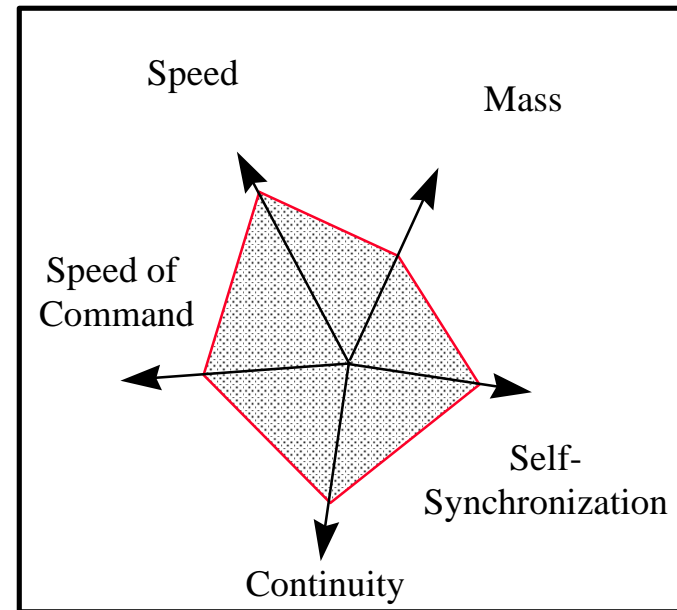
Strategy is About Selecting a Competitive Space

Strategy

Platform Centric Warfare
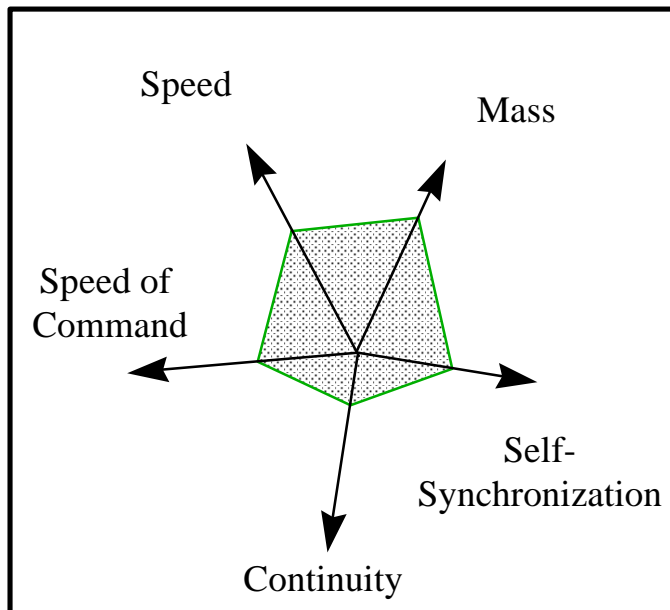
Network Centric Warfare
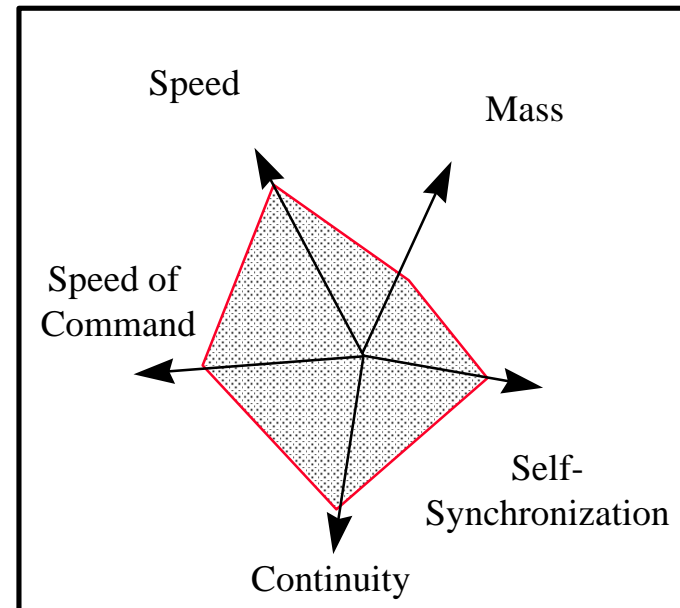
Strategy is About Selecting a Competitive Space

Attrition vs. Speed of Command
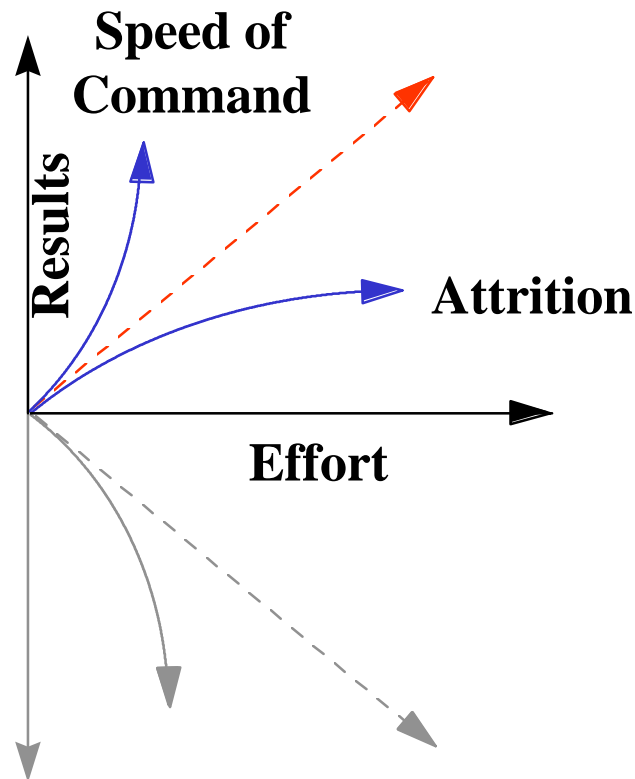
- Methods of achieving "Speed of Command"
  - Overwhelming early effort
  - Learning by gaining knowledge and experience faster (DBA/K & IW)
  - Change initial conditions positively (early effect vs. early effort)
  - Use early victories to offset technology inferiorities
  - Lock out enemy solutions
  - Apply effort on a high speed continuum vice a step function (self- synchronized vs. command synchronized)

Attrition vs. Speed of Command

Effect of "Speed of Command" and "Learning"

Desired Execution

With Planned Synchronization

With Empowered Self-Synchronization and Learning

Speed of Command

C4ISR matched to Combat Power

Execution

Time

Lost Combat Power $(CP) = \int_a f \text{ (Execution, Time)}$

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Attrition vs. Speed of Command

"Lock Out" Adversary's Courses of Action (COA)

COA 1
COA 2
⋮
COA N
⋮
Surrender

A 1
A 4
A 5
ation
ender

A 4
ation
ender

Negation
Surrender

**Attrition:
Conflict Duration =
Month to Years**

COA 1
COA 2
⋮
COA N
⋮
Surrender

Negation
Surrender

Speed of Command

Emergence of Competition Based on Time

Attrition vs. Speed of Command
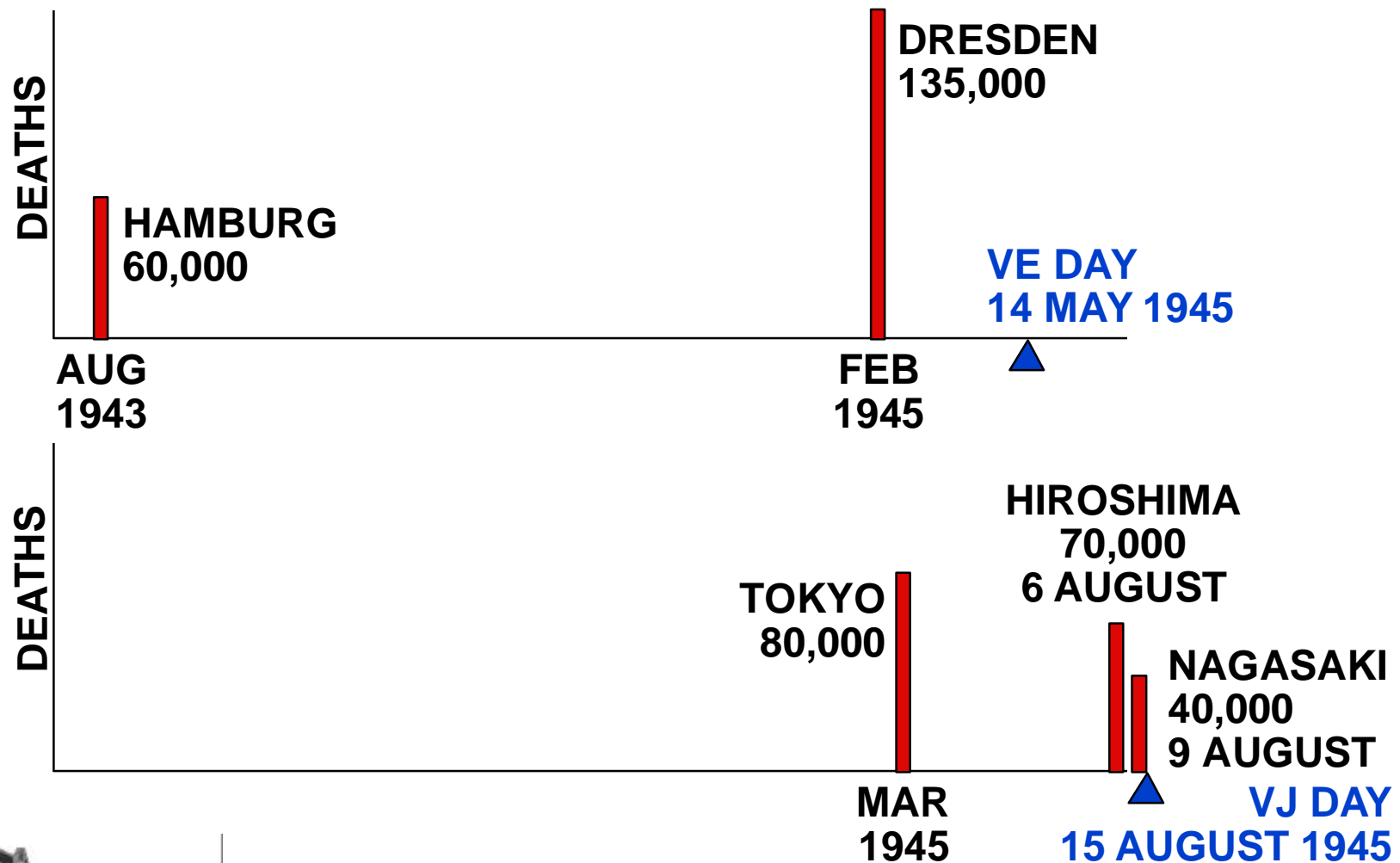
DEATHS

DRESDEN
135,000

HAMBURG
60,000

VE DAY
14 MAY 1945

AUG
1943

FEB
1945

DEATHS

HIROSHIMA
70,000
6 AUGUST

TOKYO
80,000

NAGASAKI
40,000
9 AUGUST

MAR
1945

VJ DAY
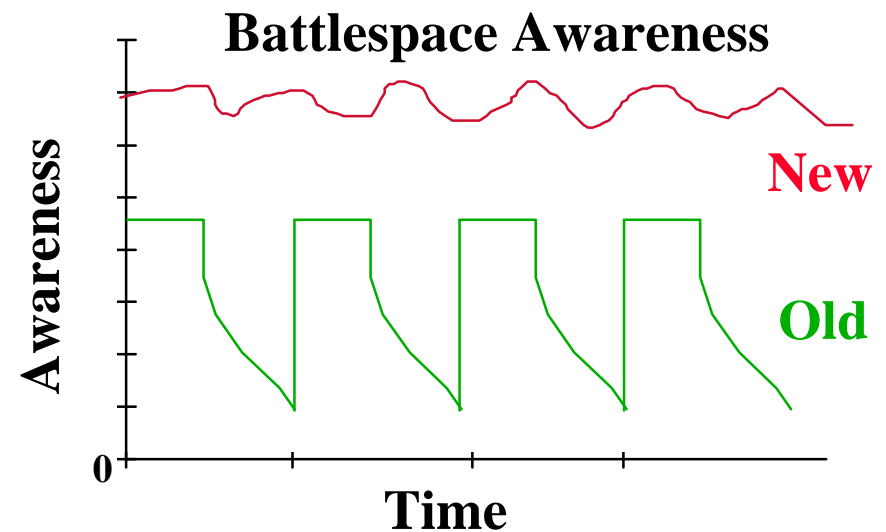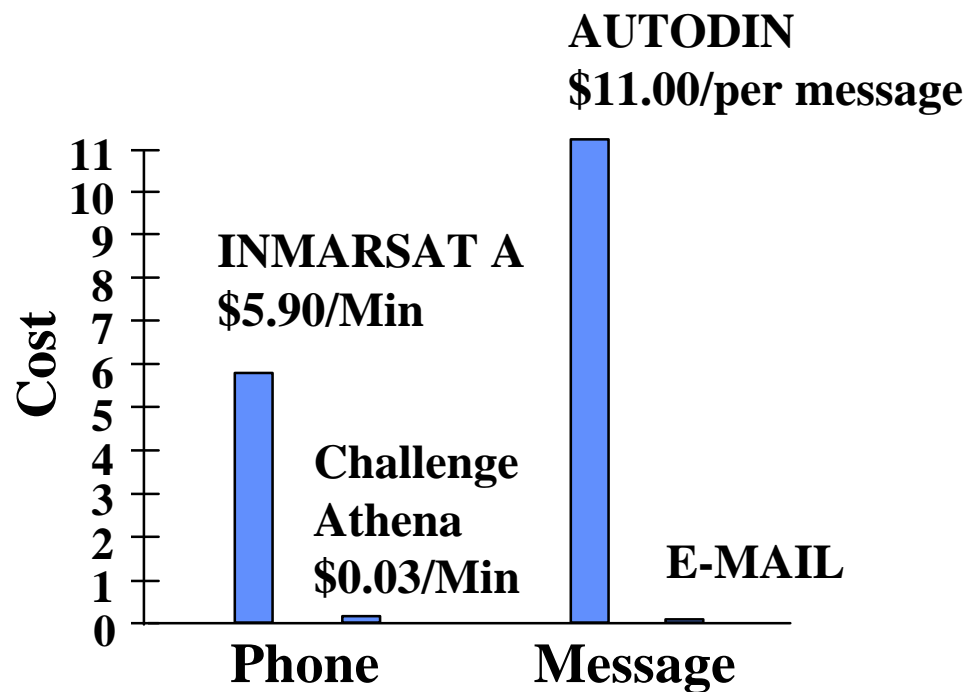15 AUGUST 1945

Copernicus

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Warfare Case Study: Taiwan Straits

- **Scope**
  - **Multi-sided live operations with high political risk and combat potential**
  - **Geographically dispersed Nimitz and Independence CVBGs, and USS Blue Ridge**
  - **Required extensive C7F, CTF 70, and USCINCPAC staff coordination**
- **Observations**
  - **Evidenced successful technology assimilation ➡ coevolution**
  - **Evolution of Admiralship as a result of increased Battlespace Awareness**
  - **Timeline compression**
  - **Simultaneity**
  - **Collaboration**
  - **Graphics vs. Text**
- **Conclusions**
  - **Emergence of speed of command as decisive operational capability**
  - **Evolution of "Admiralship"**
  - **New capabilities necessitate a reevaluation of organization and doctrine**
  - **Naval and joint experimentation required**

Speed of Command: Taiwan Straits

AUTODIN
$11.00/per message

INMARSAT A
$5.90/Min

Cost

11
10
9
8
7
6
5
4
3
2
1
0

Challenge Athena $0.03/Min

E-MAIL

Phone   Message

Battlespace Awareness

Awareness

New

Old

0

Time

<u>Higher Sustained Situational Awareness</u>

- **Enhances Speed of Command**
- **Lowers Ambiguity**
- **Reduces Questions**
- **Enhances Clarity of Mission and Intent**

pernicus

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Network Centric Warfare
Increases Joint Combat Power

Results for Precision Engagement

- **Operational Impact**
  - Dramatic Early Results
  - Greatest Rates of Change in Initial Phase of a Campaign
  - Inflicts Maximum Losses on the Enemy
  - Shortens Timelines
  - Locks out Enemy Options

Improved Shooter Grid Awareness + HARM BLK 6 + ATACMS

Improved Shooter Grid Awareness + HARM BLK 6

Current Shooter Grid Awareness + HARM BLK 6

Targets Destroyed

Time

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Network Centric Warfare

Information Grid

Sensors

Objects

Control

Command & Control

Information

Information

Sensor Grid

Control

Shooters

Destroyed Objects

Information

Shooter Grid

Copernicus

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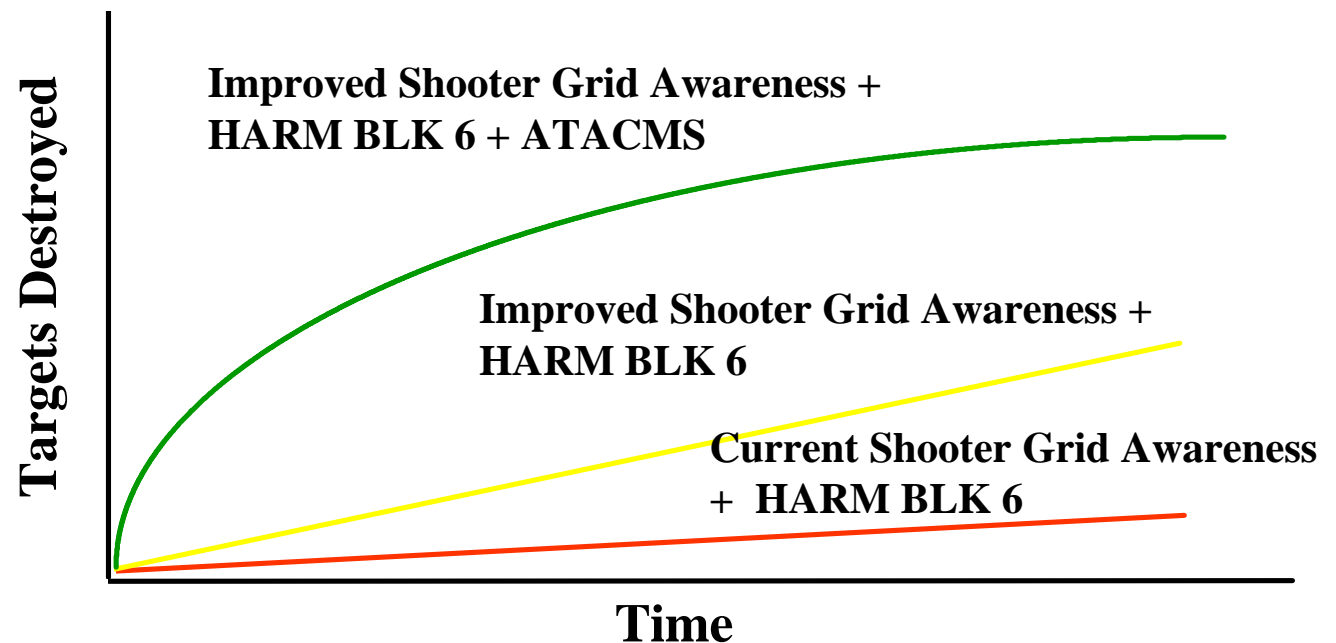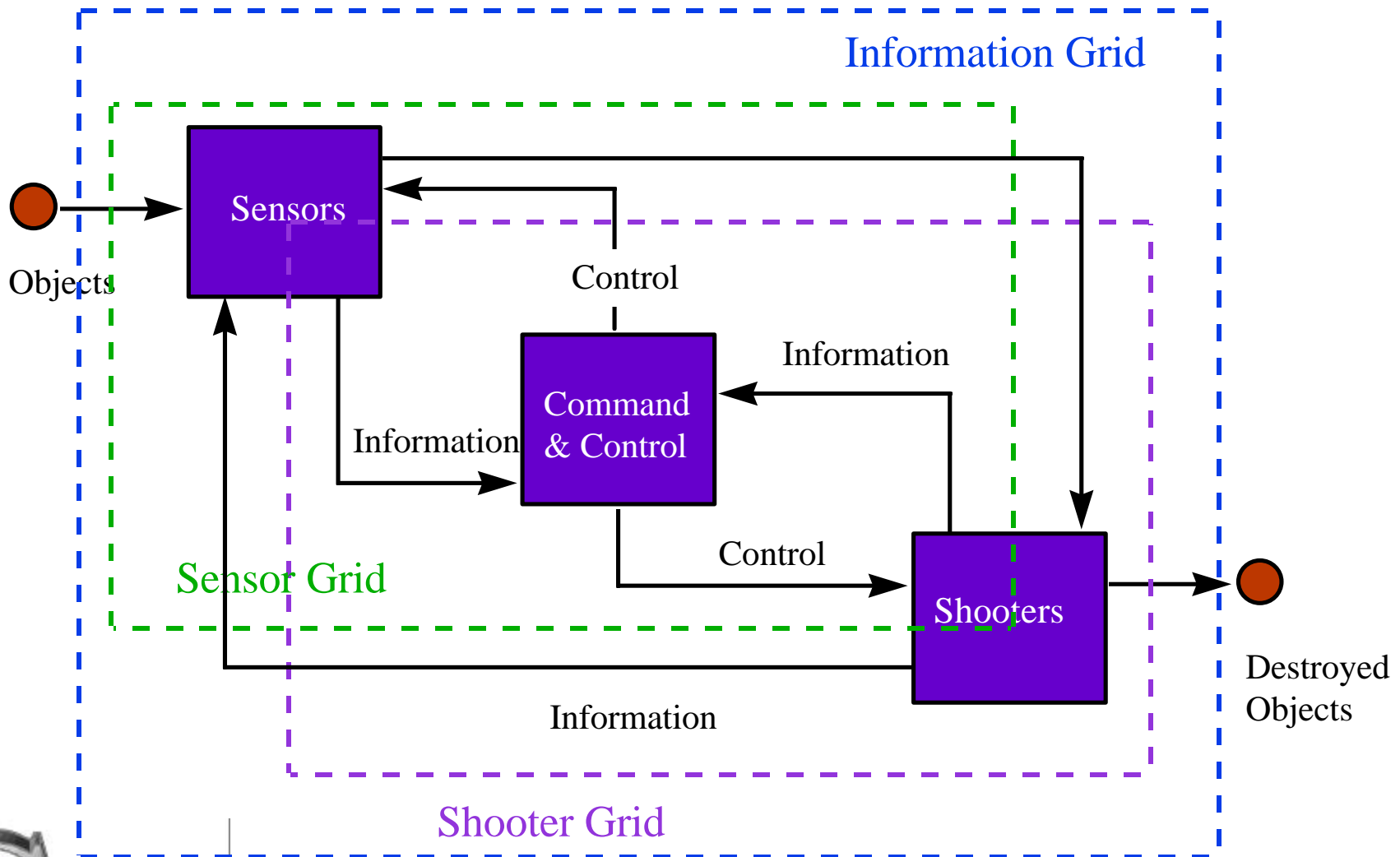
Network Centric Warfare

- ## Platform Centric Warfare

  - Platforms generate combat power

- ## Network Centric Warfare

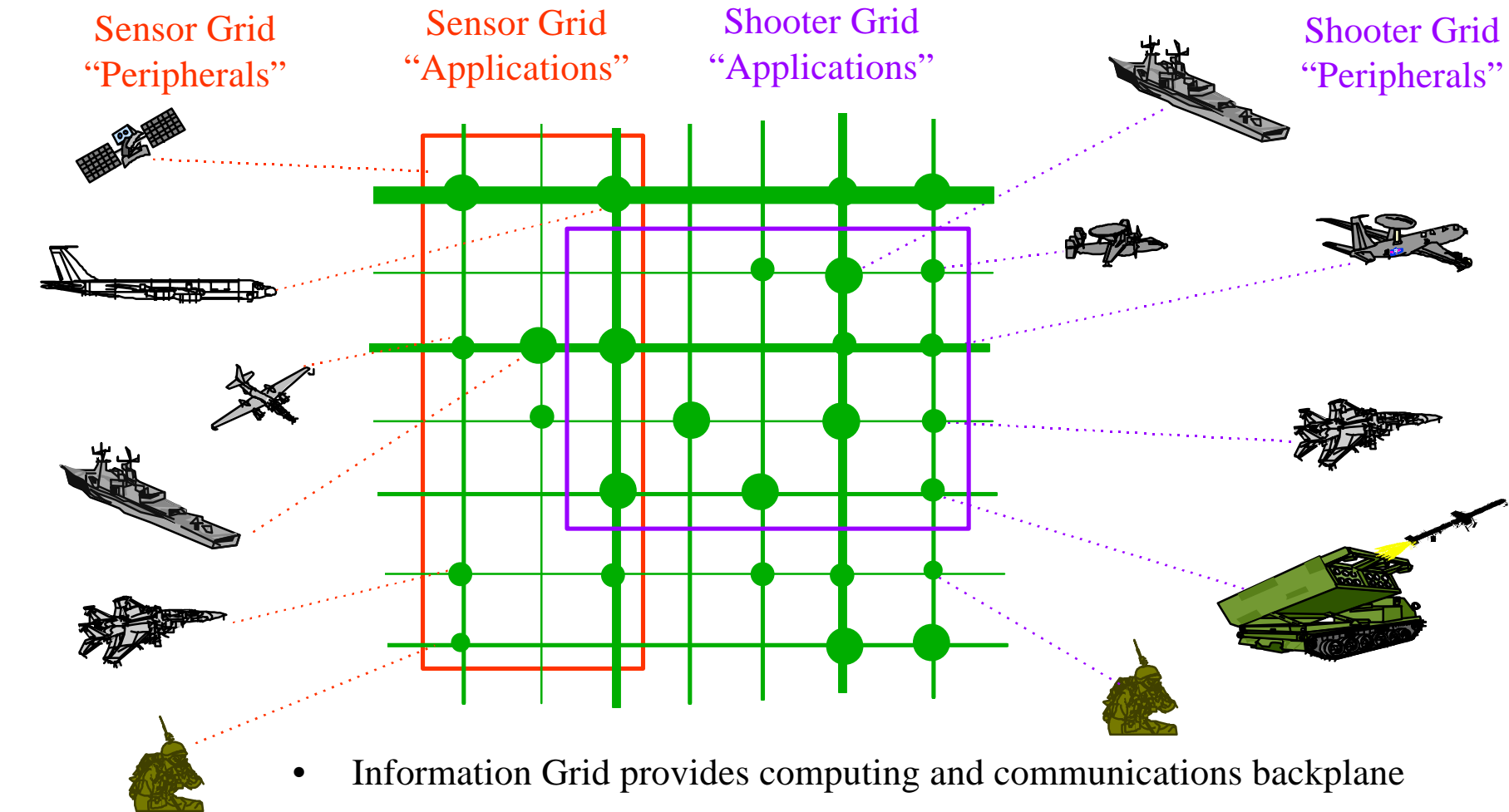 - Networked platforms generate ***increased*** combat power

Metcalfe's Law

"The power (value) of a network increases as the square of the number of nodes in the network (N^2)"

Robert M. Metcalfe: The Inventor of Ethernet

Network Centric Warfare

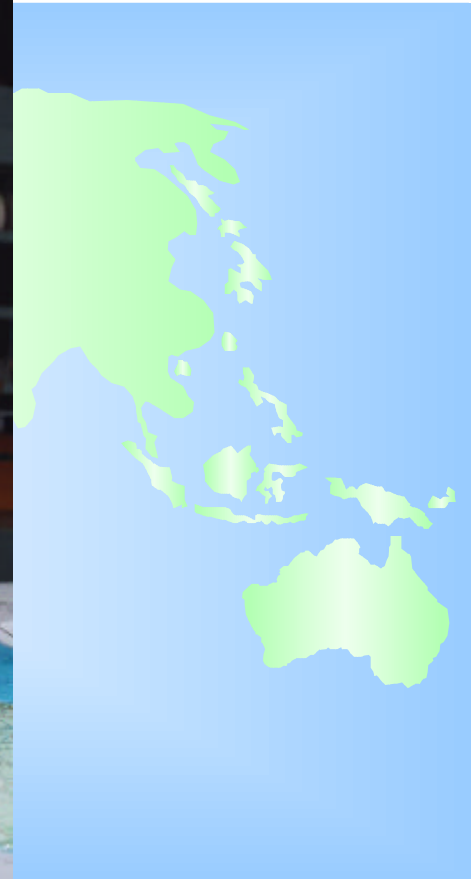Sensor Grid "Peripherals"

Sensor Grid "Applications"

Shooter Grid "Applications"

Shooter Grid "Peripherals"

- Information Grid provides computing and communications backplane
- Applications and peripherals plug into the Information Grid
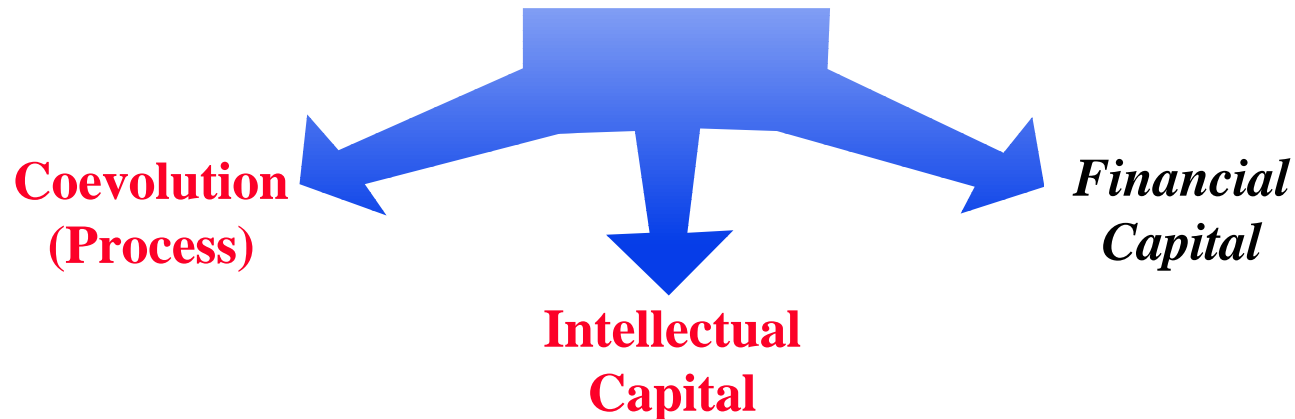
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How Do We Get There?

How the Pieces Fit

- Forward From The Sea

  - **Navy Operational Concept**

  - **Network Centric Warfare**

Coevolution (Process)

Intellectual Capital

Financial Capital

This is not about technology!
It's about resource reallocation to achieve RMA effects and secure Navy's future !

Implications: Intellectual Capital

"There is today no real career path for personnel who will manage our critical information warfighting functions. Neither do we have a training program analogous to what we have for an F-18 pilot ... In order to fix this shortfall, we must start an aggressive C^{4}ISR personnel development program, sooner rather than later."

Undersecretary of Defense (A & T)
Dr. Paul Kaminski
18 OCT 96

Changing The Way We Change

- Compelling need for coevolution
  - Organization and doctrine are lagging and decoupled from systems progress
  - Resistance is systemic and institutionalized
- Elements of a potential solution
  - Service experiments support Joint experimentation program
    - » Fleet Battle Experiments, Sea Dragon, Force XXI
  - Maritime Battle Center supports Joint Battle Center
  - Enterprise wide technology assimilation
    - » CIO provides standards for technical and operational interoperability
    - » Exploit technology: ATDs and ACTDs
  - Mechanisms for measuring progress
  - A climate which encourages innovation throughout the Fleet

Case Study: NYPD

- **Scope**
  - Two-sided live operations with high risk and violence
  - 38,000 uniformed personnel (76 Subordinate Commanders)
- **Observations**
  - Significant improvement in operational effectiveness resulting from coevolution of **organization, doctrine, and information systems**
  - Measurable results over 2 year period (1993-1995)
    - Murder   -37.5%   Felony Assault   -10.15%
    - Auto theft   -36.5%   Rape   -5.1%
    - Burglary   -23.8%   Robbery   -31.5%
    - Grand larceny   - 23.5%
- **Conclusions**
  - Technology is necessary but not sufficient
  - Underlying philosophies must change
  - Organization, doctrine, and technology must continuously adapt
    - 24 hours a day, 365 days a year
    - Near real-time feedback on what is working, and what is not working
  - If you can't measure it, you can't manage it
  - Emergence of speed of command as decisive operational capability

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Maritime Battle Center

- **Collaborative Naval environment for the co-evolution of technology, organization, and doctrine**
  - **Explore new concepts**
    - » **Operations - tactics**
    - » **Emergent capabilities**
    - » **Organization**
  - **Environment for maritime systems integration**
  - **Maritime arm of the Joint Battle Center**
- **Environment of distributed, networked, interactive Naval resouces**
- **Establish a process for technology assimilation**
- **Balance fleet experimentation with**
  - **Existing technology**
  - **Prototyp e insertion**
  - **Simulated capabilities**

Fleet Battle Experiment Alpha
March '97

- **Demonstrate New Land Attack Capabilities that can Shape the Battlespace**
  - **Arsenal Ship Combined with Carrier Airwing**
- **Address Direct Sensor-to-Shooter Connectivity Challenge**
  - **Responsive Fires for Deeply Inserted Ground Forces**
  - **Support for Developing Marine Corps / Army Operational Concepts**

Implications: Resource Allocation

- **Marginally Smaller**
- **Somewhat Leaner**
- **More Modern**
- **More Combat Capable**

SHIP IT INVESTMENT

IT 21

00

IT 21

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SHORE IT INVESTMENT
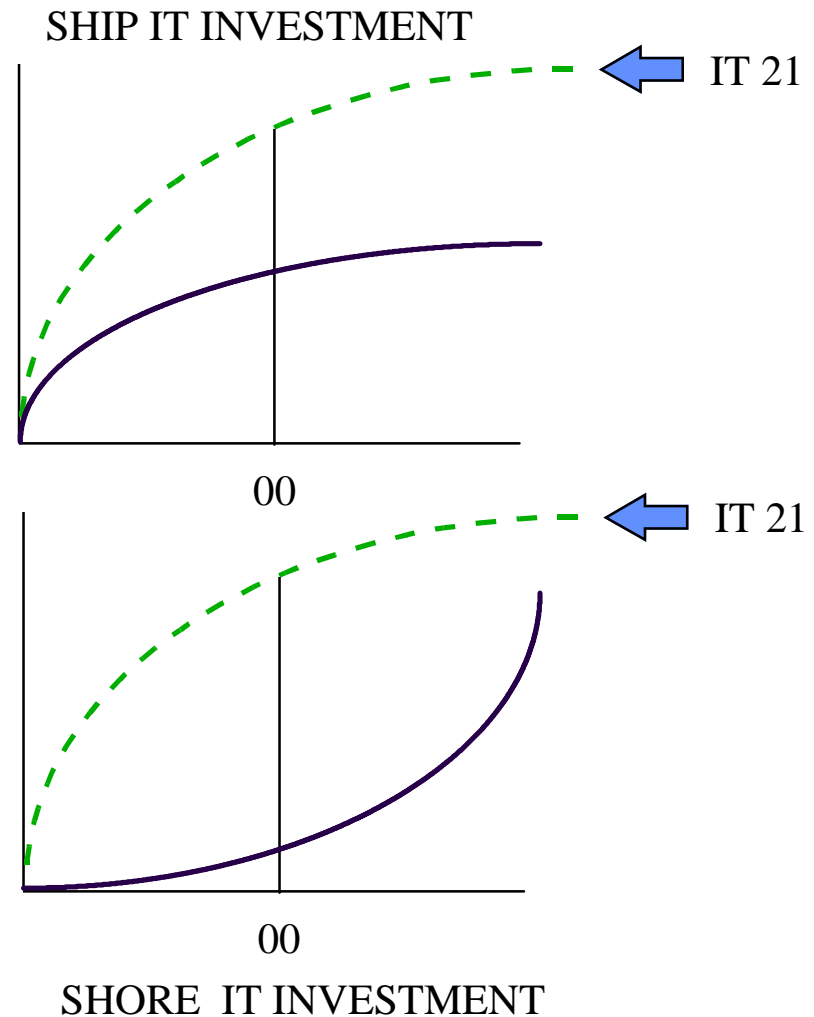
# Fleet Battle Experiment Bravo Objectives September '97

- **Examine "Ring of Fire" Concept with Advanced Sensor-to-Shooter Technology:**
  - **Full Interoperability with Marine Corps / Army**
    - » **Advanced Field Artillery Tactical Data Systems**
  - **Further Develop**
    - » **Weapons to Target Pairing (Responsiveness, Accuracy, Lethality)**
    - » **Force Inventory Management**
    - » **Interoperability with Systems Ashore**
- **Examine Advanced Real-time Airspace Deconfliction**
- **Employment of Future Land Attack Weapons (ERGM, NTACMS, Tactical Tomahawk)**

The New Business Cycle

Size of the Information Technology Sector of the Economy
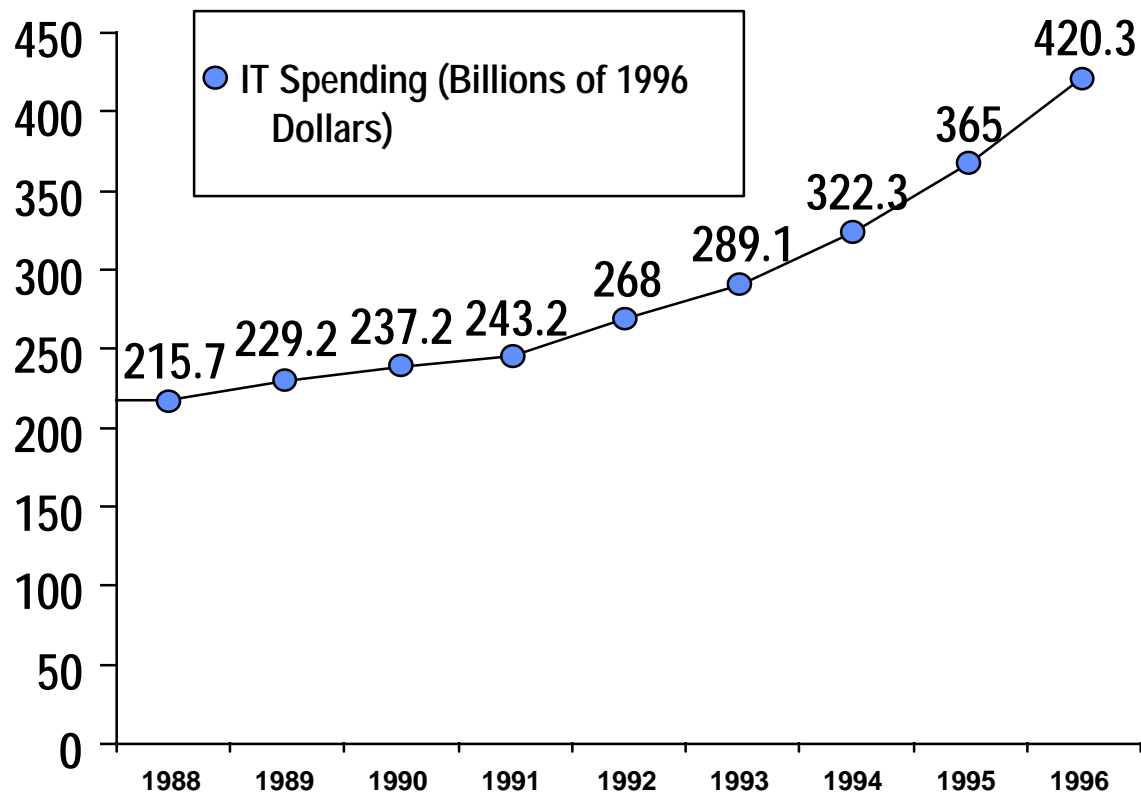
Major Information Technology Components of Gross Domestic Product

- Business and consumer spending on computers, peripherals, and communications equipment

- Net exports of IT

- Consumer spending on telephone service and cable television

- Investment in telecom services

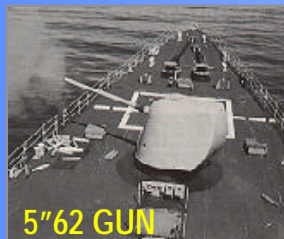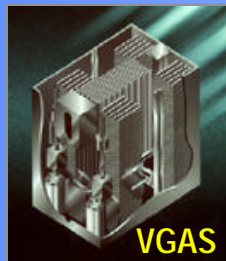**Source: "The New Business Cycle,"** *Business Week (March 31, 1997)*

Conditions

- **Necessary Condition:**
  - Information Grid

- **Necessary and Sufficient Conditions:**
  - Information Grid
  - Sensor Grids
  - Shooter Grids

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Short Term Developments

ERGM

MFSD

SM2 BLK IVA

VGAS

TACTICAL
TOMAHAWK

SEAMLESS C4I

AADC

5"62 GUN

BATTLE FORCE TACTICAL TRAINING (BFTT)

SCHOOLHOUSE

TERMINAL HOMING

AEGIS CG MISSILE INITIALIZATION & MIDCOURSE

COMPOSITE TRACK DEVELOPMENT
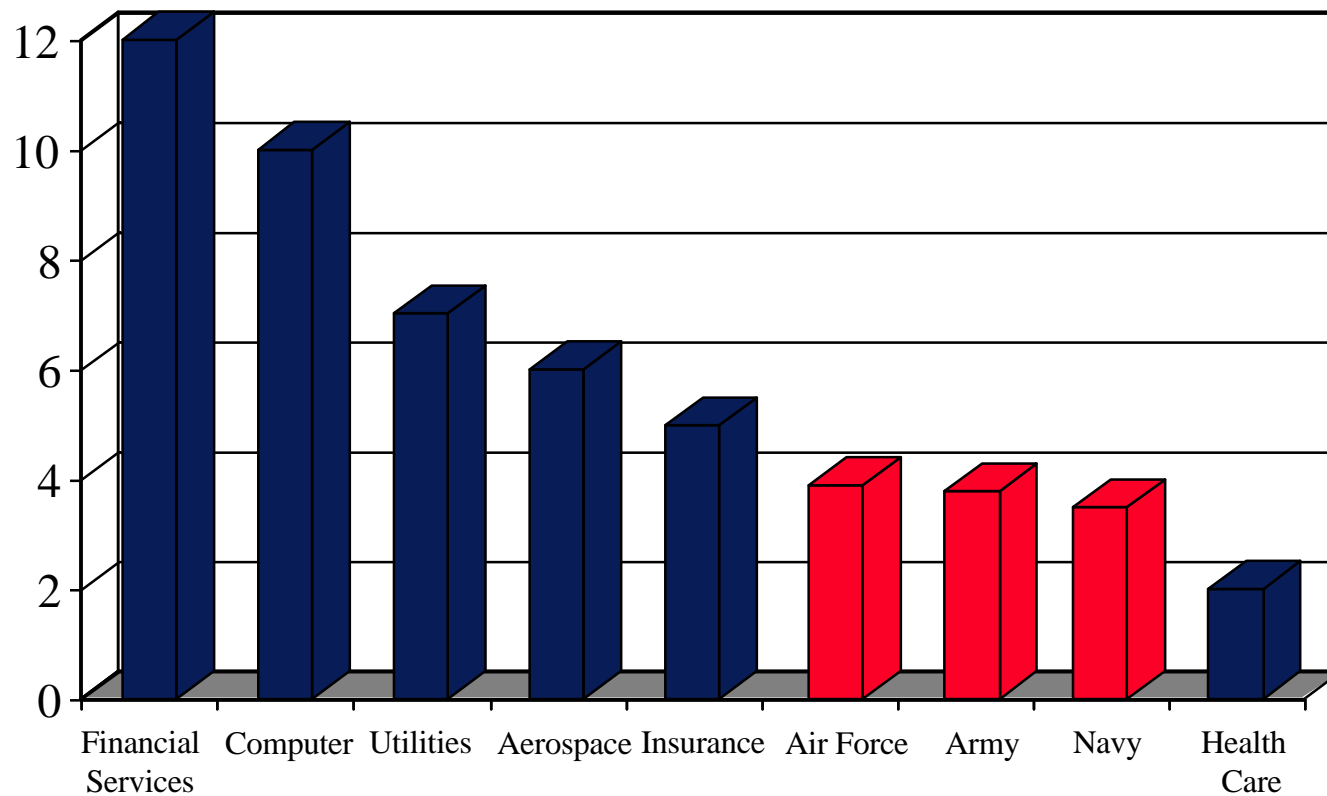
AEGIS BLOCK UPGRADE
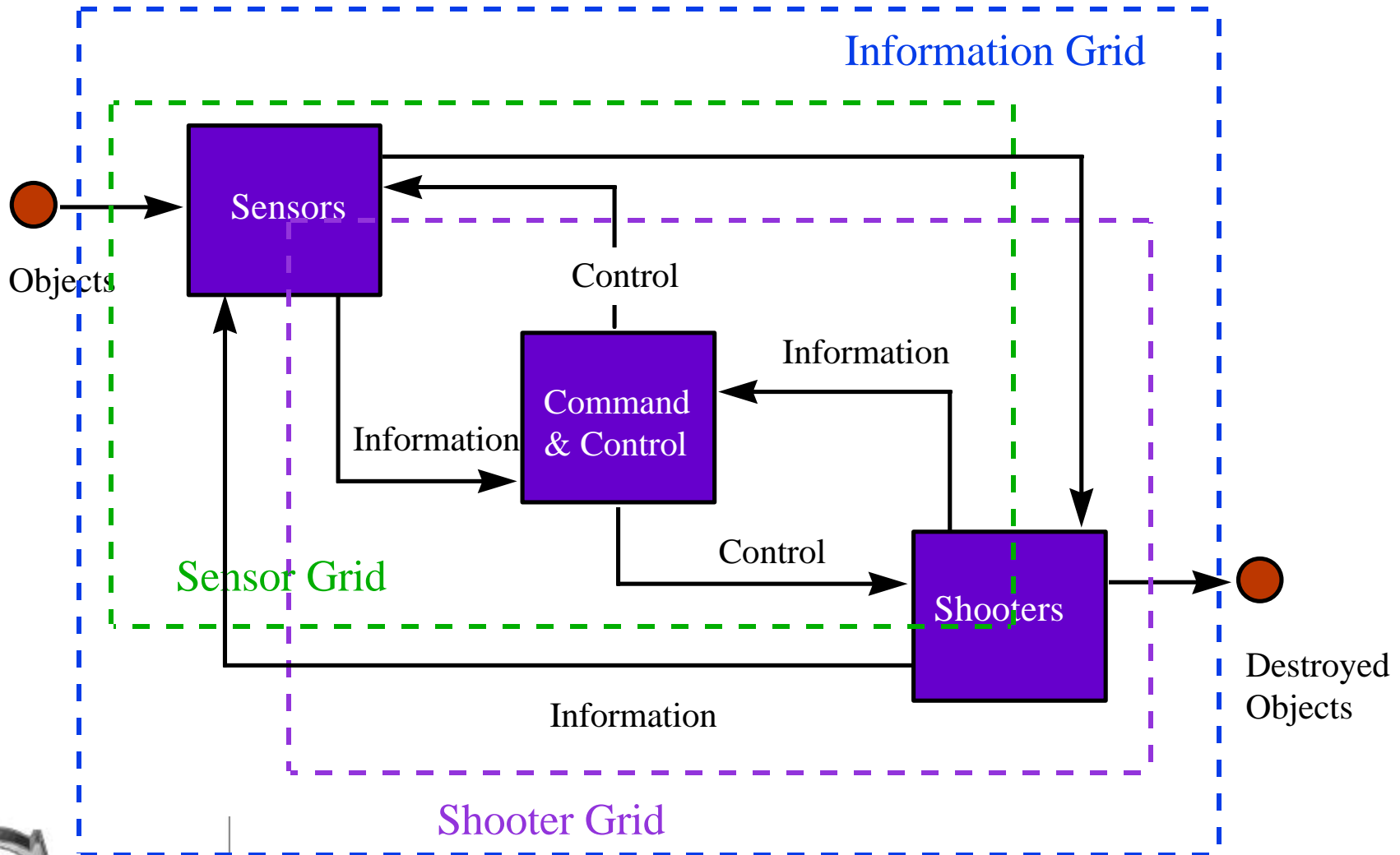
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IT Investment

Percent of Operating Expenses on Information
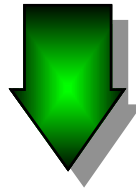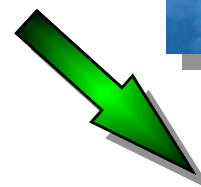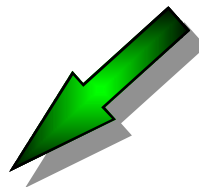Technology in Commercial Sector

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Network Centric Warfare

Navy Aircraft Transitions

Single Mission

⬇

Multi-mission

Greater Lethality
- 50 strike A/C
- Sortie generation
- All precision
- JDAM/JSOW
- Payload

More Affordable
- Cost of ownership
- GOTS - LANTIRN
- COTS
- Commonality - JSF

Greater Survivability
- Low observable
- SEAD - EA-6B
- IDECM
- Standoff
  - SLAM-ER

Bottom line:
"Greater return on investment."

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Conclusions

Coevolving Ecosystems

- **Economy**
  - **Changing Dynamics of Economic Growth**
- **Business**
  - **Changing Dynamics of Competition**
- **Warfare**
  - **Changing Dynamics of Competition**
  - **A Revolution in Military Affairs**
    - » **Platform Centric Warfare** ➡ Network Centric Warfare

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Conclusions

"The only thing harder than getting a new idea into the military mind is getting an old one out."
-- BH Liddell Hart --